Fully Exclusive Measurements of Quasi-Free Knockout Reactions With ^{12}C *

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A novel experimental method of measuring quasi-free knockout reactions in inverse and complete kinematics is being developed as an ideal way to study single-particle structure of exotic nuclei. First results from the observation of (p,2p) reactions with a benchmark ^{12}C beam at 400MeV/u were reported previously [1, 2]. The reaction manifests itself in a strong spatial correlation of the emerging nucleon pair and the residual nuclear system carries the information about the single-particle states involved in the reaction. In particular, the internal momentum of the knocked-out proton can be extracted by measuring the recoil momentum of the (A-1) fragment. The same information can be obtained redundantly from the kinematics of the outgoing proton pair. Figure 1 illustrates the correlation between these two methods applied to the case of a proton knockout from the valence p-shell in ^{12}C.

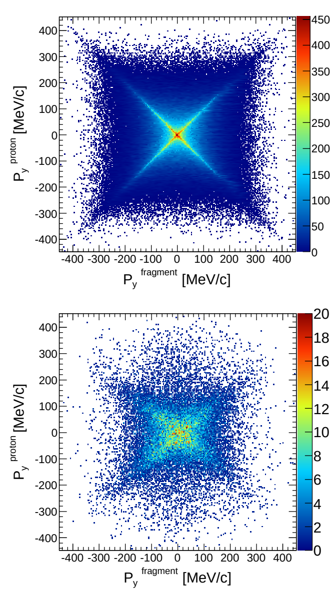

Figure 1: Correlation between the internal momentum component reconstructed via outgoing proton pair and the recoil momentum component of ^{11}B fragment from the same reaction. Top figure shows the kinematical simulation and the bottom figure is the experimental data. The cross-like shape is due to uncertainty of which one of the two protons is knocked out.

* Supported by GSI - TU Darmstadt cooperation, HIC for FAIR and BMBF (05P12RDFN8, 06DA7047I)

A detailed simulation of the experimental response has been developed based on Geant3 and FAIRroot/R3Broot software packages [3]. The improved geometrical description includes aluminum casing of NaI crystals in the Crystal Ball detector, which is aimed at the detection of outgoing protons. Additionally, copper holding structure for the silicon trackers, target-wheel motor and other materials surrounding the reaction target have been introduced into the simulation. An event generator for quasi-free scattering reactions with the proper kinematics has been implemented in the simulation code. The results of the simulation are compared to the experimental data as shown in Figure 2. The absolute efficiency for the simultaneous detection of two protons in the Crystal Ball is found to be 62±2 %.

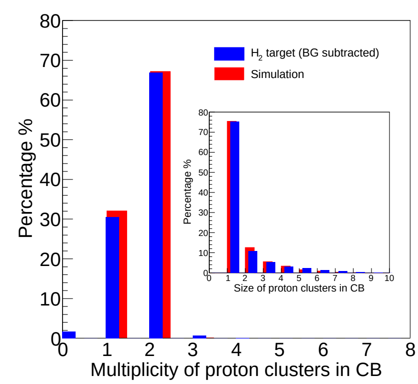

Figure 2: Simulated and experimental multiplicity distributions of high-energy proton hits (clusters) in the Crystal Ball under the condition to observe at least one non-zero signal in any crystal. The inset figure illustrates the number of crystals forming individual clusters in the case of two-proton hits.

Further development of the simulations will concern the response of the detector with respect to γ-rays accompanying the reactions. Theoretical calculations of the reaction cross sections and the momentum distributions are also under development.

References

[1] V. Panin *et al*, GSI Scientific Report 2010.

[2] V. Panin *et al*, GSI Scientific Report 2011.

[3] http://fairroot.gsi.de/